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EPA's Pollution Prevention R and D Approaches and Insights into the Chemical Process Industry

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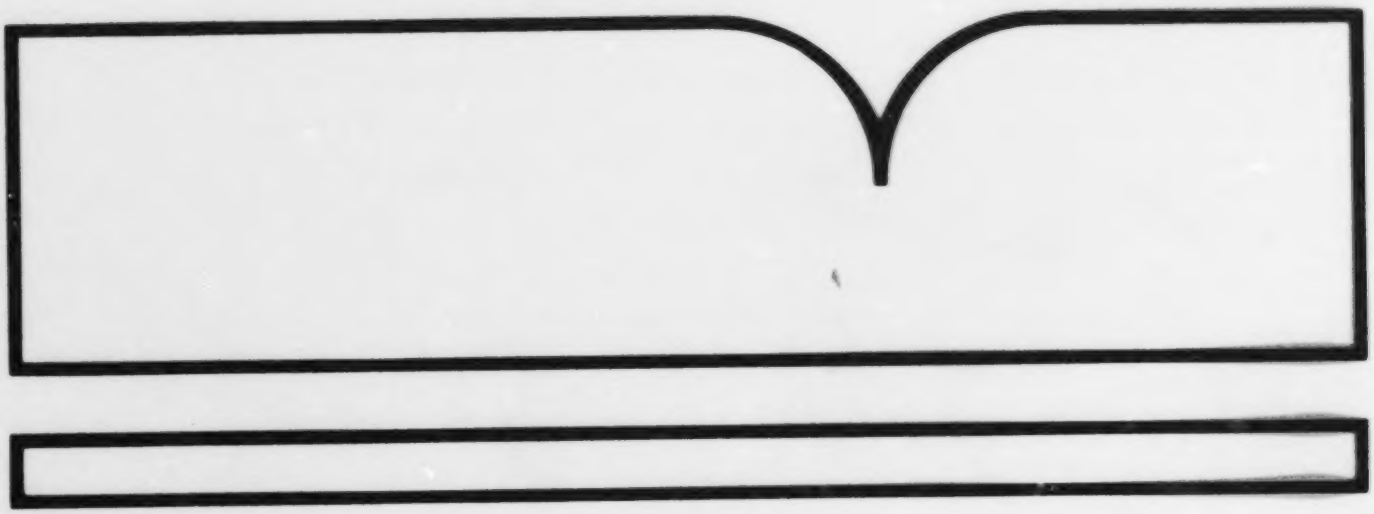

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EPA'S POLLUTION PREVENTION R&D APPROACHES AND INSIGHTS INTO THE CHEMICAL PROCESS INDUSTRY

by

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A paper to be presented at the
American Institute of Chemical Engineers
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Since 1988, the USEPA has established a pollution prevention R&D program to work with states, local governments, regional and federal agencies, and industry to encourage the identification, development and demonstration of pollution prevention technologies and methods to reduce wastes. The author will provide an overview of the chemical process industry effort to reduce wastes, review the USEPA pollution prevention research program and projects, and describe approaches to reduce wastes in chemical plants.

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ABSTRACT

Chemical Engineers face major research challenges associated with the imperative to protect and improve the environment. These challenges include designing optimal, less polluting chemical plants and processes, improving air quality through research, managing hazardous wastes responsibly, and developing \ulti-media approaches to reduce the chemical risk to human health and the environment.

Since 1988, the U.S. Environmental Protection Agency(USEPA) has established a pollution prevention R & D program to work with states, local governments, regional and federal agencies, and industry to encourage the identification, development and demonstration of pollution prevention technologies and methods to reduce wastes. The author will provide an overview of the chemical process industry effort to reduce wastes, review the USEPA pollution prevention research program and projects, and describe approaches to reduce wastes in chemical plants.

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INTRODUCTION

The reduction or elimination of pollution is not a new concept for the USEPA in reducing the health and environmental risks associated with pollution. Since the passage of the Hazardous and Solid Waste Amendments in 1984, the Agency has been refocusing its environmental protection strategy from traditional end-of-the-pipe control approaches toward pollution prevention. The term "pollution prevention," refers to the reduction or elimination of pollutant discharges to the air, water, or land. Pollution prevention approaches to environmental protection include:

- Eliminating pollutants by substituting non-polluting chemicals or products(e.g. material substitution, changes in product specifications),or altering product use

- o Reducing the quantity and/or toxicity of pollutants generated by production processes through source reduction, waste minimization, and process modifications

- o Recycling of waste materials(e.g., reuse, reclamation techniques)

Pollution prevention approaches do not include treatment and disposal methods.

Prevention, including source reduction and recycling offers a framework for solving environmental problems and enhancing cooperative efforts. By its very nature, prevention requires a great deal of information sharing and cooperation. For example, a joint agreement between AMOCO and the EPA started this past spring 1990 at AMOCO's petroleum refining complex in Yorktown, Virginia. The purpose is to look at pollution prevention alternatives and to find places in the air, water and waste permitting process where pollution prevention could play a role in the way a permit is written. In another EPA assisted project, the Ecological and Toxicological Association of Dye Stuff Manufacturers is searching for substitutes for azo and other dyes used in the leather, paper, and printing industries. USEPA also contributes to a research center at the University of North Carolina at Chapel Hill and to the American Institute of Chemical Engineers' new Center for Waste Reduction Technologies in New York City. EPA's Office of Pollution Prevention in April awarded $ 7 million in grants to states and universities to supplement existing pollution prevention programs and to help start new ones.

EPA's Office of Research & Development is also funding a number of pollution prevention programs including ones for product and process research, recycling and reuse research, socioeconomic research, anticipatory research, and technology transfer/technical assistance. The Agency spent $ 2.4 million in fiscal 1989, with $ 5.4 million budgeted for this year, and $ 9.1 million next year. The base research program is housed in the Pollution Prevention Research Branch (PPRB) within the Risk Reduction Engineering Laboratory (RREL) in Cincinnati, Ohio. This paper will later describe this program.

CHEMICAL INDUSTRY TARGETS

In the Chemical Process Industry worldwide, there is a clear movement toward pollution prevention as a means for reducing environmental problems. Top executives of several leading chemical companies including Du Pont, Dow, 3M, Monsanto, and Union Carbide have set tough corporate goals on emissions and placed much of the responsibility for meeting them in the hands of their technical experts.

For example, Monsanto Company has committed to reduce its air emissions worldwide by 90 percent by the end of 1992. In addition, Monsanto Chemical Co. plans a 70 percent reduction in all organic and toxic inorganic emissions by the end of 1995. The baseline in the U.S. will be the 1987 SARA Title III emissions report. SARA, the Superfund Amendments and Reauthorization Act, was enacted in 1986 and requires manufacturers to report annual toxic chemical releases to various environmental media and chemical transfers off-site for treatment by others.

The USEPA heartily supports the establishment of voluntary goals by these industry leaders to reduce or eliminate pollutants. 3M's goal is a 90 percent reduction in all emissions by the year 2000 using 1987 as the base year. Union Carbide expects to cut chemical releases to the environment and waste shipments by 57 percent by 1993. Du Pont took a proactive role by committing to a complete phase-out of fully halogenated CFCs by no later than the turn of the century.

To meet these goals, the challenge to the chemical industry is to find cost-effective technologies. For existing product lines, the search for effective engineering solutions has been a venture up the process stream. For example, Monsanto made process changes at an acrylonitrile-butadiene-styrene (ABS) plant that cut emissions by almost 1.3 million lb/yr. Du Pont Co. cut its plastics waste disposal by 50 million lb/yr through tighter equipment and process controls and finding markets for off-spec material. (1)

Clearly, to meet corporate goals the pressure will be on industry's R&D community, engineers, and process chemists to come up with new technological answers. Process technology in the chemical industry has gone through significant changes in the past two decades, perhaps most visible is the end-of-the-pipe controls and treatment technologies that have reduced emissions. The chemical process industry has focused on yield improvement and cost reduction for years and has optimized many of the product lines especially for high-volume or very valuable products. However, to see significant decreases in wastes, it may take a quantum jump in technology. For example, Union Carbide's UNIPOL low-pressure gas-phase polyolefin process is one of the lowest waste-generating technologies of its kind. The process generates 97 percent less total waste than the older high-pressure process. (2)

It will take a concerted effort by all sectors of society to realize the full potential of the benefits of pollution prevention. These benefits are recognized by many large companies in the chemical industry. Large companies invest in finding ways to minimize or recycle the waste generated by their production processes to the extent that it makes economic sense. Smaller companies, on the other hand, may not have the knowledge, resources, or technical capability to conduct such research. For those small facilities, the USEPA can play a valuable role in conducting research into processes, products, and recycling/reuse and then transferring the new technology widely within the industry.

The author will next provide an overview of current research activities in the USEPA Pollution Prevention Research Branch located in Cincinnati, Ohio.

THE USEPA POLLUTION PREVENTION RESEARCH PROGRAM

The EPA has defined six fundamental goals for the Pollution Prevention Research Program. These goals are contained in a report, Pollution Prevention Research Plan: Report to Congress (3), submitted by the EPA to the Congress in response to a specific requirement in the Agency's 1989 appropriation. These goals build upon existing pollution prevention research efforts, and broaden the research scope to enable the Agency to identify, develop, and

demonstrate, and transfer effective pollution prevention technologies and techniques. These goals are to:

1. Stimulate the development and use of products that result in reduced pollution.

   This goal focuses on the pollution prevention problems related to the use and disposal of specific products. Although products are often considered to include only manufactured items, as used here, the term also includes chemicals used in manufacturing processes and service industries; packaging for parts, commodities, manufactured items; and fluids and gases used as solvents, carriers, refrigerants, coatings, lubricants, and additional items of commerce. These materials often are not viewed as wastes or industrial discharges, but do, in fact, impact the environment and pose a risk to health.

2. Stimulate the development and implementation of technologies and processes that result in reduced pollution.

   Numerous pollution prevention opportunities exist in the chemical industry. This goal addresses the need to focus research activities on processes that enable broad-scale reduction in pollution generation.

3. Expand the reusability and recyclability of wastes and products and the demand for recycled materials.

   Research is needed to improve the reusability and recyclability of wastes and products, and to increase the capacity and demand for recycled materials in production processes. Such improvements will prolong the useful life of materials and reduce the environmental impacts of wastes and pollutants from all waste streams.

4. Identify and promote the implementation of effective non-technical approaches to pollution prevention.

   This research area includes socioeconomic and institutional factors that motivate behavior as they relate to incentives for adopting pollution prevention techniques. Research is needed to understand the roles of non-technological factors in implementing pollution prevention approaches and their impact on the effectiveness on pollution prevention programs.

5. Establish a program of research that will anticipate and address future environmental problems and pollution prevention opportunities.

   Research is needed to assist EPA in anticipating and responding to emerging environmental issues and to evaluate new technologies that may significantly alter the status of pollution prevention

programs in the future.

6. Conduct a vigorous technology transfer and technical assistance program that facilitates pollution prevention strategies and technologies.

   It is imperative that the results of research investigations conducted under this program or by industry and academic research programs are communicated to appropriate audiences.

Currently, the Pollution Prevention Research Program within the Office of Research & Development is broken down into six areas that correlate to these six program goals. They are:

TABLE 1 - POLLUTION PREVENTION RESEARCH FUNDING, FY90

	%	$ M Dollars
Process Research	34 %	1.836
Products Research	26 %	1.404
Socioeconomic	18 %	.972
Technical Assistance	15 %	.810
Recycling	4 %	.216
Anticipatory	3 %	.162
Total FY90=	100 %	$ 5.400

Products Research Program

The focus of research efforts in this program area is specifically on products and their pollution burdens, as opposed to just the processes by which products are manufactured. This research provides the methods for conducting assessments of the life cycle environmental implications of products, identifies opportunities for reducing the hazardous and toxic components of all classes of products, and encourages the development and use of environmentally preferable products. These efforts are directed at both identifying the pollutants generated in the course of manufacturing products and at evaluating the manner in which products may become pollutants in the course of their lifespan.

Essentially all products are potential pollutants, and it is desirable to develop methods that reduce the pollution impacts associated with products by insuring that:

- Unnecessary releases and disposal of toxic or otherwise hazardous products are eliminated

- Products are not used or discarded unnecessarily or in inappropriate ways

- Product designs that result in the release or disposal of hazardous or toxic materials are eliminated whenever possible.

- Toxic or otherwise harmful components are eliminated from product formulations, whenever possible.

- Product designs that result in the generation, release, or disposal of excessive quantities of aquatic or atmospheric pollutants or of excessive amounts of solid waste are discouraged in favor of less polluting designs.

That portion of the PPRP that addresses products, and encourages the development and adaption of "environmentally friendly products" is in its formative stages. Some examples of projects under development are:

- Summary of Background document for Clean Products Research

  A background study has been completed to summarize the state of knowledge of methodologies for assessing the overall environmental impacts from manufacturing, using, and disposing of consumer products. This document is to be used as a source of information to focus the Agency's programs to evaluate the impacts of products on the environment.

- Comparative Risk of Consumer Products for Pollution Prevention.

  This project is a three year cooperative effort between ORD, the Office of Solid Waste and the Office of Air Quality Planning and Standards. It is designed to quantify comparative risks among various categories of products. The final result from the project is envisioned to be guides for consumers and producers to use in evaluating relative environmental risks of various products.

Processes Research Program

Efforts in this area focus on identifying opportunities for preventing pollution from industrial processes and on stimulating industries to develop and implement new processes that generate less pollution.

To date, the Pollution Prevention Research Program has supported many projects to develop, demonstrate, and evaluate improved, less waste generating processes. Many projects are being implemented through the Waste Reduction Innovative Technology Evaluation(WRITE) Program, a three-year cooperative program that provides $ 100,000 / year to cooperating organizations to support demonstrations and evaluations. In 1989 WRITE agreements were developed with the states of New Jersey, Minnesota, California, Illinois, Connecticut, and Washington. In 1990, a similar agreement has been developed with Erie County, New York.

An example of a WRITE Program is the program in Illinois with the

Hazardous Waste Research and Information Center (HWRIC) in Champaign, Illinois. HWRIC is working with industry in Illinois to demonstrate and evaluate at least five innovative source reduction and recycling options. The scope of the technology evaluations include both engineering effectiveness and economic payback. The primary objective is to establish reliable performance and cost information on promising pollution prevention techniques and technologies. Five projects have been selected out of a list of over 40 companies, trade associations, equipment vendors, and consultants. Technologies include substituting water-based inks for solvent based inks in flexographic printing, evaluating soy oil-based inks in offset printing, using zinc hydroxide in place of zinc cyanide in zinc electroplating, substituting citrus cleaners for chlorinated solvents in metal fabricating and printing, and the recovery of metals and zircon sand in foundries. Also, a method to determine the degree of toxicity reduction of waste streams is being developed.

The PPRB program encourages the chemical industry as well as other industrialized sectors to be proactive and seek out opportunities to reduce the generation of wastes by utilizing waste minimization opportunity assessments. The EPA has published a manual for conducting assessments. This manual, "The Waste Minimization Opportunity Assessment Manual" (4) is available free from the PPRB. The manual was prepared for individuals who are responsible for planning, managing, and implementing waste minimization activities at plant and management levels. The research program is presently supporting several projects to demonstrate the use of this manual.

One such project is with the New Jersey Department of Environmental Protection (NJDEP) to conduct assessments at thirty (30) New Jersey companies across ten (10) industry segments. The New Jersey Institute of Technology (NJIT) is participating in coordinating the assessments. Initial industries to be studied include: chemical manufacturers, pharmaceutical, R&D facilities, metal finishing and fabrication, utilities, printing and dying and dry cleaners.

Also, the EPA in cooperation with the California Department of Health Services is producing a series of industry specific manuals that address waste minimization opportunities in a variety of industries. These manuals are in various stages of development. Four (4) manuals (paint formulators, circuit board manufacturing, hospitals, and research and educational institutions) have been completed and are available through the Pollution Prevention Research Branch. The other three (3) (pesticides, commercial printing, metal fabricators) are expected to be available in late 1990.

The Waste Reduction Evaluations at Federal Sites(WREAFS) program is an activity designed to encourage the participation of other Federal agencies in pollution prevention research and demonstration projects. Results are transferred to the private sector through the Branch's technology transfer activities. Waste minimization opportunity assessments have been conducted at the Philadelphia Navy Shipyard, Ft. Riley (Kansas) Army Forces Command, Naval Undersea Warfare Engineering Station (Keyport, Washington), the Veterans Affairs Medical Center (Cincinnati), and with the Coast Guard (Governor's Island, N.Y). Planned assessments and demonstrations are with NASA in New

Orleans, LA, with the DOE, and others. In addition, a joint USAF RD&D project seeking to obtain information for its chlorinated solvents recycling program is under way with Auburn University. The DOD and DOE work is focused on a wide range of industrial and military operations including metal cleaning, solvent degreasing, spray painting, vehicle and battery repair, ship bilge cleaning, and equipment overhaul.

In addition to supporting the WRITE, WREAFS, and Waste Minimization and Assessments Programs, the PPRB also directly supports research in many other process areas. One study will quantify pollution prevention measures by industry sector and to develop more effective tools to measure and compare pollution prevention across industries. Another study concerns the evaluation of pollution prevention technologies in the transportation industry such as used antifreeze and CFC-12 recycling and reuse in automobile garages. A third study evaluated the chemical substitution of water-base cleaners for organic solvents in a small parts cleaning operation. In this project, the PPRB in cooperation with a local company conducted a project to evaluate the substitution of a waterbased cleaner for trichloroethane and methanol. A report is available on this study (5).

Recycling and Reuse research program

The focus of projects in this program area is to stimulate the development of new recycling and reuse opportunities when environmental and health risks of toxic, hazardous, or otherwise excessively polluting substances of concern can be reduced, or energy and material conservation are possible.

Recycling and reuse of plastics is an opportunity for EPA to encourage private industry research that would significantly contribute to pollution prevention and material conservation, especially in the chemical recycling of plastics. Approximately, eight percent by weight of all municipal solid waste is now composed of plastic material. In 1988, the U.S. public discarded over 29 billion pounds of plastics. Assuming no source reduction or recycling of plastics, the figure is expected to rise to 42 billion pounds by the year 2000 (6) . The trend in industry to cope with this problem is to emphasize the expansion of reclamation based on mechanical methods of reusing plastics such as molding and extrusion. Research may be needed to explore other areas such as chemical recycling of plastics. The concept of chemical recycling entails the use of chemical methods to break plastic down to their original components which are then re-polymerized to form new polymer compositions. Recent scientific studies have indicated that through a catalytic reaction with diethylene glycol, polyester resins are broken down into short-chain polyols. When these polyols are reacted with polyisocyanates and other material, they can be converted into rigid polyurethane foam. This is an example of just one of the possibilities of chemical recycling of plastics.

There are other examples of the types of PPRP projects in the recycling area. Currently, two projects are with the U.S. Department of Agriculture's Forest Products Laboratory (FPL). The first project is designed to investigate the potential of reclaiming newsprint by means of a dry fiberizing process. It is part of a larger research program at FPL that will explore dry and /or

semi-dry paper making processes. The American Newsprint Publishing Association (ANPA), FPL, and EPA are co-funding the total program. For the dry fiberizing portion of the program, FPL is looking at three methods for disintegrating newsprint that achieve the goals of fiberizing: effective separation of fibers with minimal damage to or shortening of these fibers. The three methods are hammermilling, ballmilling, and single disk refining.

The second project will involve lab and pilot-scale work to develop commercially viable thermoformable composite products using recycled high density polyethylene(HDPE), wood flour, recycled wood fiber, and reclaimed polyester fiber. Preliminary research has produced promising results. This project will be an interagency agreement with FPL and will build on existing research to develop a variety of composite products; the most promising will be scaled-up to pilot-scale.

Socioeconomic and institutional research

This research includes sociology, economics, human behavior, and the institutional conditions that may act as incentives or obstacles to establishing pollution prevention programs. Understanding in these areas is critical to the effective nationwide implementation of pollution prevention programs. All of the Branch's projects in this area are still in the planning stages.

Anticipatory research

Three major areas of long-term research that are essential to a comprehensive pollution prevention research program are:

- Anticipating and responding to emerging environmental issues and using pollution prevention approaches to mitigate these issues.

- Evaluating emerging technologies for their potential contribution to pollution prevention and stimulating those that are preferable to existing technologies

- Evaluating the effectiveness of the Agency's pollution prevention research in meeting changing user information needs.

To date work in this area has been supported by other elements of the EPA organization. Due to limited funds, the PPRB has not emphasized such projects. However, as the program continues to mature and grow, it is expected that more research of an anticipatory nature will be done.

Technology transfer and technical assistance

Technology transfer and technical assistance are essential components of EPA's research efforts in pollution prevention. To a great extent, the success of an EPA program to encourage the development and adoption of new, more environmentally acceptable production processes and products depends on the quality and effectiveness of the information dissemination programs utilized. Information obtained as a result of the products, processes, and

recycling/ reuse research will be assembled, summarized, and distributed in formats designed to meet specific needs of the intended users.

Technical assistance to small businesses is being provided through a cooperative agreement with the University City Science Center in Philadelphia, Pennsylvania. This project has completed its first year of a scheduled three year duration. Waste Minimization Assessment Centers have been established at the University of Tennessee (Knoxville) and Colorado State University (Ft. Collins), with a third center at the University of Louisville just beginning operations. Faculty and student teams from these Centers provide waste minimization assessments at no cost to a small business lacking the expertise or resources to initiate a waste minimization program. During the first year, twelve assessments were completed including a printed circuit board manufacturer, a railroad car and equipment refurbisher, a paint and coatings producer, a plastic bag printer, and an aluminum can manufacturer. Annual savings of $ 1.28 million would result from implementation of the recommendations. Most recommendations had simple payback periods of one year or less.

To generate broad support from the private and public sectors and to achieve widespread and expeditious adoption of pollution prevention concepts, the EPA has joined with the University of Cincinnati to establish the American Institute for Pollution Prevention (AIPP). AIPP will provide a novel communication bridge between EPA and industry. The Institute is composed of a group of volunteer experts selected by their professional societies and trade associations and other groups. The members possess credentials of accomplishment in pollution prevention and are presently or have been responsible for management, plant or process design/selection or are highly knowledgeable of industrial operations. Organizations represented include the American Chemical Society, the American Institute of Chemical Engineers, and the Chemical Manufacturers Association.

Also, as mandated by the Congress, EPA has established a national clearinghouse to provide easily accessible and reliable information on waste minimization/pollution prevention. The clearinghouse contains both technical information on how to identify and implement pollution prevention opportunities, and general information conveying the message that, "We, as a society, must begin to integrate pollution prevention into the way we design, build, buy and consume. EPA's Pollution Prevention Information Clearinghouse (PPIC), collects and disseminates technical and other information through a telephone hotline and an electronic information exchange network. Indexed bibliographies and abstracts of reports, publications and case studies on pollution prevention are available. Some examples related to the Chemical Process Industry are discussed next in this paper.

CHEMICAL INDUSTRY EFFORTS

Pollution prevention methods have been practice for many years in the industry under yield improvement or cost reduction projects. Some efforts have payed off. For example, 3M has saved a net total of about $ 500 million for the first year of some 2500 projects initiated over the past 15 years. Dow Chemical Co. has initiate 168 waste reduction projects over the past three (3

) years with payback less than a year. (1)

Other efforts are provided below that show a small sampling of the pollution prevention progress industry is making in this area.

Synthetic Fibers

Du Pont's Cape Fear plant in North Carolina produces chemical intermediates that are used at their polyester fiber facility to produce Dacron. A valuable metal catalyst is used in the dimethyl terephthalate (DMT) process. The molten waste from the DMT process is injected into an incinerator to be burned at very high temperatures. The company realized the ash contained a valuable resource and entered into a joint agreement with the catalyst vendor to recover and reformulate the catalyst off site for reuse in the chemical process. (7)

In the manufacture of a nylon intermediate, Du Pont discovered a new catalyst system that made it possible to produce adiponitrile from butadiene without producing an unwanted brine by-product. The resultant process change gave a higher yield thus reducing the organic wastes and reduced by 50 percent the aqueous waste generated. (8)

Furthermore, in the manufacture of nylon intermediates, Monsanto and DuPont are offering a dibasic acid by-product from adipic acid manufacturing for use in limestone scrubbers in flue gas desulfurization. The dibasic acid by-product contains about 25 % dibasic acids, including adipic acid, succinic acid, and glutaric acid; the rest is comprised of water and minor impurities. (8), (9)

Chlor-alkali industry

ICI, at one of its plants in the United Kingdom, incorporated a reverse osmosis membrane cell which does not entail the use of mercury for chlor-alkali production. This change resulted in a 30 % reduction in energy requirements. Most importantly, the new membrane based cell produces chlor-alkali with no mercury containing hazardous waste. (10)

Photographic Products Industry

In 1988, Polaroid's Battery division eliminated mercury from the battery contained in every integral film pack. Before that time, Polaroid's battery like all carbon zinc batteries contained a small amount of mercury. The purpose of the mercury was to increase the battery energy output. Although the new mercury-free batteries offer less energy, it is enough power to operate the camera systems. (11)

Surface Coating Industry

Union Carbide's UNICARB System enables VOC emissions to be reduced 30 to 70 percent in applying high quality coatings by using supercritical carbon dioxide to replace the volatile organic solvent fraction that is used to

obtain atomization viscosity. This enables applicators to reduce the VOC emissions while continuing to use high molecular weight polymer systems. (12)

Plastic Industry

Chemical engineers usually take a hard look at critical unit operations such as distillation to improve yield, reduce costs, and therefore reduce waste loads to the process sewer. Monsanto made changes in an amino resins operation distillation train. Environmentally, the changes significantly reduced the formaldehyde loss per year in the distillation column effluent and reduced air emissions. Changes included new developments in distillation technology and significant improvements in process instrumentation and material balance control methods. In addition, removal of butanol and isopropyl alcohol contaminants in the distillation column crude provided improved operation of the methanol column and the elimination of an azeotropic mixture. (13)

Also, it is reported that Du Pont and Waste Management of North America will clean, sort, and recycle plastics recovered from municipal solid waste streams in the upper MidWest. The primary plastics will be polyethylene terephthalate (PET) used in soft drink bottles, and high density polyethylene (HDPE) used in milk, water, and a variety of household cleaning product containers. (14)

Pulp and Paper industry

Process modifications to the chlorination step have significantly lowered the concentrations of dioxin and furan in bleached pulp at Westvaco Corporation Charleston, South Carolina. Chlorine is added to pulp in three charges instead of one so that the concentration remains low and it is quickly used up in the reaction thus inhibiting the formation of dioxin and furan. The modified process has been installed at three of Westvaco's mills. (15)

LOOKING TO THE FUTURE

EPA's pollution prevention research effort will continue to be developed as an integrated multi-media program to address hazardous and non-hazardous wastes across all industries. EPA's pollution prevention initiative will by no means be exhaustive but will attempt to identify and foster pollution prevention approaches whether it be technology bottlenecks, institutional or economic. The EPA Science Advisory Board summarized EPA's role in pollution prevention as follows:

> "EPA is the only entity that has a clear mandate to conduct research to gather information on effective approaches and to transfer that information to all who could use it nationwide. This information collection, evaluation, and dissemination role is a key component of the research function and one that EPA is uniquely suited to serve. In short, no individual local government or private business is likely to fund research needed by many local governments and private businesses to help reduce their waste streams. Yet, as more and more elements of our

society become directly involved in the business of risk reduction, such research clearly is needed."

As the Agency and the nation moves through the 90's, it is clear that more emphasis is needed on pollution prevention. We must work closely together to identify and share opportunities and technology for pollution prevention. We need to do everything we can to clean the environment and still be competitive in the global marketplace. Chemical engineers have a major role in this effort and may hold the solutions to many of the nation's and the world's environmental problems.

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REFERENCES

1. G. Parkinson, Reducing wastes can be cost effective, Chemical Engineering, Vol. 97, No. 7, pp. 30-33.

2. Toward Environmental Excellence: A Progress Report, Union Carbide Corporation, December 1989.

3. Pollution Prevention Research Plan: Report to Congress, EPA/600/9-90/015, USEPA, March 1990.

4. Waste Minimization Opportunity Assessment Manual, EPA/625/7-88/003, July 1988.

5. L.Brown, J.Springer, M.Bower, "Chemical Substitution for 1,1,1-trichloroethane and methanol in manufacturing operations, April 1990.

6. Characterization of MSW in the U.S, 1990 update, Office of Solid Waste, EPA-530-SW-90-042, June 1990.

7. R. Schecter and G. Hunt, Case Summaries of Waste Reduction by Industries in the Southeast, Waste Reduction Resource Center for the Southeast, Raleigh, N.C., July 1989.

8. G.J. Hollod and R.F. McCartney, "Waste Reduction in the Chemical Industry: Du Pont's Approach," Journal of the Air Pollution Control Association (JAPCA), Volume 38, pp 174-179, 1988.

9. C. T. Chi and J.H. Lester, " Byproduct Utilization in Adipic Acid Manufacture," MCA Waste Minimization Workshop, New Orleans, LA., 1987.

10. L.C.Gardner, D.Huisingh, Waste Reduction through material and process substitutions: progress and problems encountered in industrial implementation, Hazardous Waste & Hazardous Materials, Vol. 4, No. 1, 1987.

11. A Report on the Environment, Polaroid Corporation, May 1989.

12. D.C.Busby, C.W.Glancy, K.L.Hoy, A.C.Kuo, C.Lee and K.A. Nielsen, Supercritical fluid spray applications technology: a pollution prevention technology for the future, Waterborne and higher solids coatings symposium, February 1990.

13. Firm offer new life for old PET, Chemical Engineering, Volume 97 No. 3, page 48C.

14. Reducing dioxin and furan in papermaking, Chemical Engineering, Volume 97, No. 3, page 17.